

Innovation And Knowledge Flows In Healthcare Ecosystems: The Portuguese Case

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Abstract: Innovation has come a long way since the times it was defined just as a new idea. Nowadays, innovation activities comprise a lot more, from new products and/or services to improvements in organisational business models. The healthcare sector is no exception. This leads public authorities to increase their investment in innovation, research and development in the healthcare sector. The rising of internal and external collaborations between hospitals and other parties calls for a specific analysis on how the healthcare innovation environments behave and how knowledge flows within them are managed. This study, through the lens of the ecosystem theory, aims to study how a healthcare innovation ecosystem can be activated and knowledge flows are managed to ensure that all the parties are benefited. For that purpose, it presents a case study based on a set of three meetings of Portuguese stakeholders inserted in innovation healthcare ecosystems. With this work it was possible to observe that the healthcare innovation ecosystem can be analysed from different perspectives. The interaction with the different stakeholders allowed to identify possible partners to be involved in innovation activities (e.g.: hospitals, universities, research centres, start-ups). This paper suggests possible roles for the different parties along the innovation funnel as well as what they can do in each phase. Using a case study approach, it is possible to compare different contexts and identify best practices on the management of healthcare innovation ecosystems. Also, it becomes evident the need for more effective knowledge management to ensure that hospitals and the other parties meet their goals and play a relevant role in the ecosystem. Although this paper provides guidelines for action, it lacks implementation of the suggestions in a specific context. As such, this paper aims to serve as a basis for future research on the study of hospitals' innovation ecosystems and underlying knowledge flows, in different contexts to achieve best practices for its effective management.

Keywords: healthcare innovation ecosystem; ecosystem theory; knowledge flows; knowledge transfer; stakeholders; hospitals

1. Introduction

The ability to innovate is often considered a key factor to achieve sustained growth, especially in an ever-increasingly ageing society that values wellbeing and health (Tolstykh, Gamidullaeva and Shmeleva, 2020). This leads public authorities to increase their investment in innovation, research and development in the healthcare sector, calling for a specific analysis on how the healthcare innovation environments behave and how knowledge flows within them are managed. Despite the importance of the theme, and although the subject of innovation ecosystems and its underlying flow of knowledge has been thoroughly studied in other contexts, very few of these studies address the specific case of healthcare, namely hospitals.

Nowadays, hospitals need to innovate not only internally (through the offering of new services, for example), but also externally, through collaborations with other organisations in the development of new solutions. As a result, the analysis of innovation ecosystems has benefited from extensive literature. The advantage of using the ecosystem approach relies on the fact that it considers the complexity of the business network established among a large number of actors and the interdependencies among them (Adner, 2017; Cavallo, Ghezzi and Balocco, 2018), .

The aim of this study is to analyse how it is possible to activate innovation and knowledge flows in healthcare ecosystems and ensure that all the participants benefit from its results, through a case study based on a group of Portuguese stakeholders. Moreover, this work aims to elaborate a set of best practices for the different stakeholders of the healthcare ecosystem that can promote innovation and knowledge flows among the entities. These guidelines relate to the different stages of the innovation process so that stakeholders can identify what to do along the process. Moreover, we would like to thank the 26 participants in this study, for their opinions and involvement.

The paper is structured as follows: first, an introduction to the paper subject, followed by the methodology applied. Thirdly, the theoretical background. After, the results are presented, followed by its discussion, implications and limitations and conclusions.

2. Theoretical background

2.1 Innovation and knowledge flows in the healthcare sector

Innovation can be defined from various points of view, leading to the development of different types of innovation process models (Žižlavský, 2013; OECD/Eurostat, 2018). For this study, innovation is defined as the ideation and/or implementation of a new or improved product/service, process or business model (Dias and Escoval, 2014; Kelly and Young, 2017).

Depending on their goals, organisations must decide how they intend to innovate, using closed or open innovation (Chesbrough, 2012). This means that firms can choose between following an approach where they must generate ideas, develop and market them on their own, or an approach where they can use external ideas and even resources to maximize their knowledge (Bianchi *et al.*, 2011; Adner, 2017).

Nowadays, open innovation is often associated with the concept of globalisation and the development of new and innovative solutions in the organisations (Bogers, Chesbrough and Moedas, 2018). Using this approach, managers must decide between an inbound or an outbound open innovation strategy. It means that an organisation can choose to open the innovation process to knowledge exploration, or opening the innovation process to knowledge exploitation (Lichtenthaler, 2011). In both cases, there is a need to develop relationships with external parties (Bianchi *et al.*, 2011; Ribeiro and Nagano, 2018).

According to literature, hospitals appear to choose more open innovation approaches to deal with today's challenges (e.g. ageing people, need for more personalised treatment) (Secundo *et al.*, 2019; Peter *et al.*, 2020). Nevertheless, healthcare professionals (mainly doctors and nurses) do not always welcome external knowledge. This happens due to a common misunderstanding of the innovation processes' goals, which can lead to the boycott of innovation activities in the organisation (Hellström *et al.*, 2015; Carlucci, Mura and Schiuma, 2020).

To improve the current paradigm, hospitals managers need to open their institutions and collaborate with other parties to achieve better innovation results (Dias and Escoval, 2013, 2014; Secundo *et al.*, 2019). However, when establishing collaborations with other parties, tensions in the system can emerge due to a misalignment of the interests of the participants (Lantos and Simon, 2018).

Since it has been argued that the economics of the 21st century are mainly characterised by knowledge, information and innovation, the knowledge and technology transfers are not only important within the organisation, but also between different organisations. (Žižlavský, 2013). The way these transfers are managed will strategically impact both sides of a collaborative partnership and the operationalisation of the innovation ecosystem (Shaw, 1988; ISO, 2019).

As such, hospitals need to manage not only internal knowledge but also the knowledge emerging from the networks created due to the "interaction and co-creation" across hospitals and other stakeholders in the system (Bianchi, *et al.*, 2011; Lichtenthaler, 2011; Sieg, Wallin and von Krogh, 2019). Due to being a process driven service, the healthcare sector offers the opportunity to implement practices for the management of knowledge flows to improve existing processes (Bordoloi and Islam, 2012). However, due to the number and proximity among stakeholders involved in an innovation process the management of knowledge is challenging, since the different parties are known for playing different roles on an innovation ecosystem during the value creation process (Bordoloi and Islam, 2012; Lambooy and Hummel, 2013; Tranekjer, 2017; Scaringella and Radziwon, 2019).

The establishment of a sustainable ecosystem between different players and partners can lead to the creation of an unique environment, allowing a better business performance for all the involved parties (Järvi, Almpantopoulou and Ritala, 2018) acting as a key driver for the innovation process (Suominen, Seppänen and Dedehayir, 2019). Still, to achieve successful goals, the interested parties must understand what each can do in the process and anticipate interdependencies that arise from the process (Wilson and Doz, 2012; Thune and Mina, 2016). As important as identifying the network that can be formed during the innovation process, is the

identification of partners and the correct management of the ecosystem through the identification of the ties that can be established and the knowledge flows that can be enacted (see Figure 1). Since knowledge management has the power to improve processes in the healthcare sector, the implementation of a mechanism to manage it is considered an essential tool to achieve efficiency in all areas (Bordoloi and Islam, 2012; Massaro, Dumay and Garlatti, 2015).

Hospital managers must be aware that their institutions work in an unique context in which stakeholders are vast and act different from the private sector (Riege and Lindsay, 2006; Massaro, Dumay and Garlatti, 2015). So, the management of knowledge flows must consider elements related to people, processes and technology (Edwards, 2011; Ford and Yoho, 2020). Moreover, the implementation of knowledge management practices can help to improve efficiency in all areas of the sector (Massaro, Dumay and Garlatti, 2015; Shabbir and Gardezi, 2020).

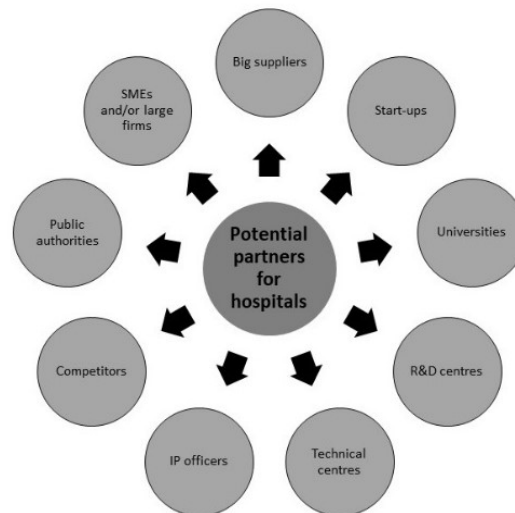


Figure 1: Suggested actors in the healthcare ecosystem. Adapted from ISO 56003:2019

2.2 Ecosystem Theory

In literature it is mentioned the need to study in more detail the healthcare ecosystem in what relates to innovation creation and its underlying knowledge flows (Secundo *et al.*, 2019). This concept first emerged from the field of biology and refers to a complex system, hosting a number of entities and elements (Adner, 2017) and continued to be improved until it reached the management literature in mid 1990s (Cavallo, Ghezzi and Balocco, 2018; Scaringella and Radziwon, 2019).

Considering the necessities of the current business world, the innovation ecosystems are gaining importance as a lever to foster innovation in organisations (Secundo *et al.*, 2019; Suominen, Seppänen and Dedehayir, 2019; Arenal *et al.*, 2020). As mentioned previously, hospitals and healthcare institutions need to reposition themselves in the way they interact with society. To support this process, the concept of innovation ecosystems can play a guiding role. Since it includes a larger variety of actors, and the knowledge and the technology transferred among them resides in the interactions among the members, the ecosystem theory can help to implement new approaches (Secundo *et al.*, 2019). The effective management of knowledge flows ensures the safety of sharing while guaranteeing that the “unresolved questions are not missed” (Maženyte and Petraite, 2020).

Although theoretical concepts on healthcare innovation ecosystems are formally developed, very few case studies have been found in literature (while searching TOPIC “healthcare innovation ecosystem” or “healthcare knowledge ecosystem” and TOPIC “case study”). The works found are listed in Table 1, as it may help future research.

Table 1: Papers found using TOPIC “healthcare innovation ecosystem” or “healthcare knowledge ecosystem” and TOPIC “case study”

Year	Title	Author(s)
2020	Opening new pathways for innovation in healthcare	Pavani, C.; Plonski, G.A.
2019	Responsible for responsibility? A study of e-health start-ups	Oftedal, E.M.; Foss, L.; Iakovleva, T.
2018	Understanding Convergent Innovation in Healthcare Technologies: Relational Models for Nascent Ecosystems	Phillips, M. A.
2018	Intellectual property evolution and innovation ecosystem as effective tools in strengthening Indian healthcare sector	Dixit, T.; Srivastava, S.; Sahu, S.; Selvamurthy, W.
2018	Introducing a governance framework for the innovation ecosystems. The case of the public healthcare innovation ecosystem in the Lombardy Region	Barbarossa, M.
2018	A methodology for case study research to analyse innovation platforms in South African healthcare sector	Dondofema, R. A.; Grobbelaar, S.
2017	Development of an Interoperable Exchange, Aggregation and Analysis Platform for Health and Environmental Data	Alakraa, M.
2017	Orchestration roles to facilitate networked innovation in a healthcare ecosystem	Pikkarainen, M.; Ervasti, M.
2017	The roles of Innovation Network Orchestrators in Healthcare Ecosystem	Pikkarainen, M.; Ervasti, M.
2017	Networked commercialisation of medical innovation – personalised medicine	Korhonen, R.
2016	Governance of Digital Innovation in Regional Healthcare Innovation Ecosystem	Pistorio, A.; Gastaldi, L.; Locatelli, P.
2016	Digital health innovation ecosystems: From systematic literature review to conceptual framework	Iyawa, G. E.; Herselman, M.; Botha, A.
2015	Personal health systems technologies: critical issues in service innovation and diffusion	Schartinger, D.; Miles, I.; Saritas, O.
2013	Accelerating digital health innovation: Analysing opportunities in the healthcare innovation ecosystem	Cohen, E.
2012	Workforce for innovative regulatory science	Olson, S.; Claiborne, A. B.
2011	Making the most of public services	Levy, C.

As such, this article aims to contribute to this gap in knowledge by bringing together the elements of the Portuguese healthcare ecosystem, identify its internal strengths and weaknesses and analyse its external opportunities and threats. So, the following research question emerged: *How it is possible to activate innovation and knowledge flows in healthcare ecosystems and ensure that all the participants benefit from its results?*

3. Methods

Considering the Portuguese healthcare sector, there is a clear lack of innovation initiatives that connect hospitals with the academia, the industry, the government and the civil society (Dias and Escoval, 2014; Moreira, Gherman and Sousa, 2017).

To validate this perception, a literature review was carried focused on innovation in the healthcare sector and/or ecosystem and the underlying knowledge flows, as well as the role of stakeholders in the ecosystem and a brief review of the theories supporting the study.

To help answering the research question, elements from organisations that belong to the healthcare ecosystem (such as hospitals, universities/research centres, pharmaceutical companies, small and medium enterprises (SMEs), start-ups, public authorities and patients’ associations) were selected to participate in meetings through three rounds. This technique allows to select individuals that have experience on a certain subject, according to a set of criteria. In this case, each individual had to be member of an entity that is included in the Portuguese healthcare ecosystem and with experience on the area. Moreover, through the social interactions of the group, the results obtained tend to be better than individuals face-to-face interviews (Rabiee, 2004)

With this qualitative technique, the individuals were able to provide their ideas and opinions regarding the management of innovation in healthcare ecosystems in Portugal. The work group was composed by 26 individuals from different sectors. The inclusion of elements from diverse organisations allows to have a sample

composed by organisations from the four helices of the quadruple helix model, namely society, government, academia and industry (Carayannis and Campbell, 2010; Hasche, Höglund and Linton, 2019).

Tables 2 and 3 show the sample characteristics based on gender and the function of each participant in the organisation. Table 4 characterizes the participating entities by framing them into the Quadruple Helix Model.

Table 2: Sample characteristics based on gender

Gender	Masculine	Feminine
Percentage	61,5%	38,5%
Number	16	10
Total	26	

Table 3: Sample characteristics based on function at the organisation

Function	Number
Professor	4
Manager	11
Director	4
Board Member	3
Consultant	2
Researcher	2
Total of participants	26

Table 4: Sample characteristics of the participating entities based on the Quadruple Helix Model

Quadruple Helix Entities	Number
Society	1
Government	7
Academia	7
Industry	5
Total of participating entities	20

The meetings were guided by information from the literature and personal knowledge of the performance of the healthcare innovation ecosystem in Portugal.

The first meeting focused on presenting the national context, thus identifying the strengths and weaknesses of the health innovation system and identifying best practices.

The second meeting complemented and validated the findings of the first meeting and made an initial discussion of the best practices identified.

The third meeting finished the SWOT/TOWS matrix and the best practices identification.

From the discussion, a set of strengths and weaknesses of the innovation ecosystem was identified as well as a set of opportunities and threats in the environment surrounding the ecosystem, that lead to the development of a TOWS matrix (Weihrich, 1982). The results of this matrix enabled the identification of lines of action that not only address the research question, but also lead to medium-term vision of how the healthcare ecosystem can be managed so that innovation can be achieved, and knowledge can flow among the members of the ecosystem.

4. Results and discussion

First, there was the need to identify the elements involved in the innovation process, considering the well-known “innovation funnel” process that describes how ideas are generated, turned into concepts, manufactured and them commercialised.

For this study, the state-owned hospital innovation ecosystem was the one considered. However, other healthcare innovation ecosystems can be identified such as the case of private hospitals and nursing homes, among others.

Before providing the actions that each actor can play along the process, it must be defined the position of hospitals in it. Traditionally, state-owned hospitals are considered secondary actors in the development of new solutions, as suggested in Figure 2. This means that they enter in the process when contacted by other players and only perform the functions which are determined by others (Secundo *et al.*, 2019). The results show evidence from the Portuguese case.

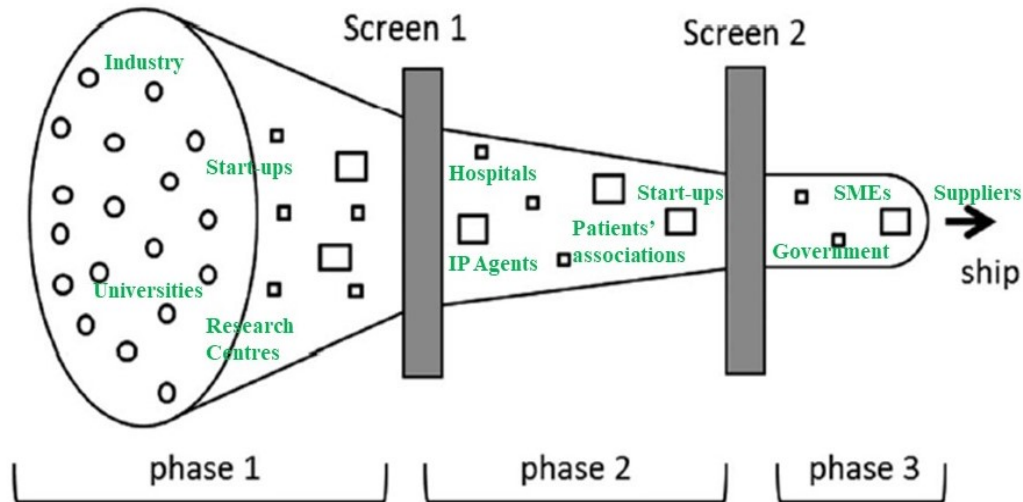


Figure 2: Suggested traditional position from hospitals in the healthcare innovation ecosystem. Adapted from (Bagno, Salerno and da Silva, 2017)

The Portuguese healthcare sector has a public portal that highlights the importance of innovation in healthcare. However, a health innovation strategy does not exist. These leads, in one hand, to the non-involvement of patients in the assessment of innovative solutions and, on the other hand, to SMEs and start-ups not being able to focus on the development of products that can be scaled up by the ecosystem.

Also, the individuals identified that the knowledge creation process is focused on the academia with few contacts with the healthcare institutions. The healthcare sector in Portugal is mainly composed by state-owned hospitals, which do not have a competitive nature and tend to ignore the need to incorporate innovation and the underlying knowledge when adopting new technologies. Therefore, as identified in the literature, technological innovation adoption is frequently prevented by the lack of partnerships between healthcare institutions and other parties in the ecosystem (Tidd and Bessant, 2009). One reason for this is that hospital managers have no incentive to hire innovation managers that can structure these relationships.

Although it seems that the healthcare sector in Portugal is facing serious difficulties, the people involved in this study identified some opportunities to improve it. Portugal can learn from other European countries who are leaders in innovation in the sector (e.g., see Øvretveit *et al.*, 2012). It exists the opportunity to develop and incorporate new approaches that can lead to new and innovative business models, in which hospitals play a more central and decisive role, as identified in the literature (Dias and Escoval, 2012). Also, even though the EU data policy is restrictive, Portugal has the capacity to manage the existing data from patients, hospitals and other stakeholders through the development and implementation of new technological services. Therefore, a need for the introduction of new information systems that allow data standardisation, without compromising individual identification emerges. This can allow to define behavioural patterns and provide a better service, through the efficient management of knowledge flows (Laihonen, 2015).

The main contribution of this paper is the analysis of the results through a TOWS matrix. This technique allows to identify actions to leverage strengths and seize opportunities (SO); assess how threats can be accessed by the strengths (ST); understand which opportunities are not explored due to weaknesses (WO) and identify which threats are impacted seriously by the weaknesses (WT), as it can be seen in detail in Appendix 1.

Such technique helped to draw a set of guidelines to improve innovation and knowledge flow in the healthcare ecosystem while identifying actions that each player can perform in the healthcare ecosystem were identified,

allowing to redefine the role of hospitals in it. These guidelines (Tables 5, 6 and 7) were defined considering each phase of the innovation process. As a result, the innovation funnel was redrawn in Figure 3, considering a more active role of hospitals in the ecosystem.

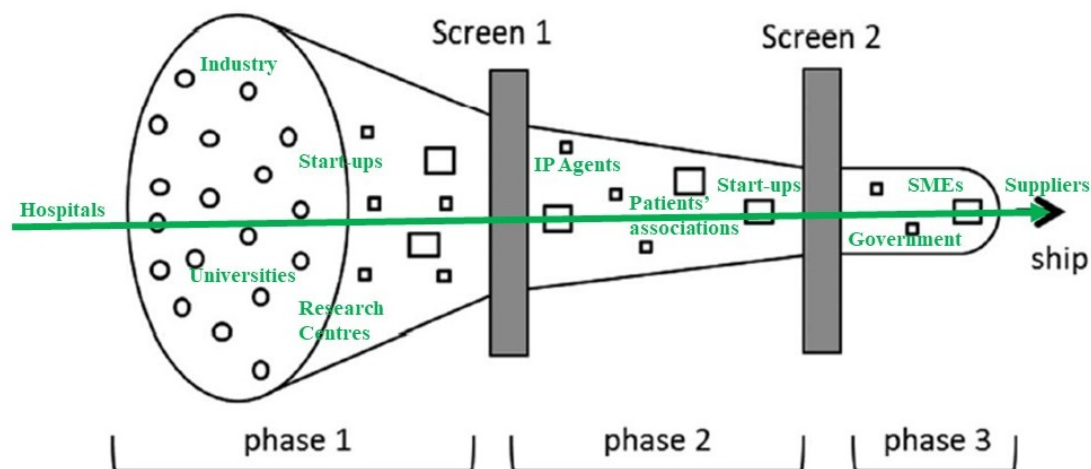


Figure 3: Suggested new hospital position in the healthcare innovation ecosystem. Adapted from (Bagno, Salerno and da Silva, 2017)

The first stage of the innovation process (ideation) refers to the product/service/process idea generation and selection, considering the viability and importance for the organisation. The aim of this stage is to collect as many ideas as possible to increase the possibilities of improvement by the organisation. Therefore, the goals of the parties involved as well as the responsibilities and the role each can play in the process must be well defined (Hakkarainen and Consulting, 2014; Bagno, Salerno and da Silva, 2017).

Table 5: Actors and suggested actions in the first phase (ideation) of the innovation process

Actor of the ecosystem	Actions suggested
Universities	Encourage the participation of the students in innovation projects in the healthcare sector; Inclusion of management disciplines in the healthcare courses to enable commercialisation of research results; Promote the integration of medicine students in projects from other areas such as management to empower them with other skills; Promote dynamics of contact with different entities of the healthcare innovation ecosystem to study how knowledge is managed; Promote training in entrepreneurship activities.
Research centres	Test and validate pilots and projects in the market; Make the results from projects and pilots available and accessible for companies that are willing to transform them into commercial products.
Start-ups	Define their role in the innovation process and operate according to the resources available (human, financial, engineering, etc); Promote the participation of elements from staff in conferences and other relevant events related to the development of innovative approaches in the healthcare sector to be updated; Hire knowledgeable people in the healthcare field to become relevant in the market and know how to operate in it.

Moving to the second stage (proof of concept), in this phase there is space to develop the concept, detailing the project and requirements for further development and implementation, according to defined criteria. The ideas must be matched according to the goals of the ecosystem, while choosing approaches to test the concept (Hakkarainen and Consulting, 2014; Bagno, Salerno and da Silva, 2017).

Table 6: Actors and actions suggested in the second stage (proof of concept) of the innovation process

Actor of the ecosystem	Actions suggested
Start-ups	Select the most suitable stakeholder for the project and enter networking and knowledge transfer agreements with other stakeholders; Identify funding opportunities that enable the creation of marketable products.
Patients associations	Promote the participation of patients in clinical tests to assess the performance of innovative solutions; Promote the use of information systems in the healthcare sector by patients to express their needs and opinions; Promote the advantages for the patients that result from participating in the innovation ecosystem.
Intellectual Property (IP) Agents	Must be integrated in the innovation process since its beginning to guarantee that the objectives of the project do not duplicate existing results and that the intended results are properly protected; Must act as neutral parties, guaranteeing that each participant in the ecosystem is properly rewarded for its involvement and has a stake in the IP generated and receives adequate royalties from the commercialisation of IP.

The last phase of the innovation funnel refers to the manufacturing, distribution and sales, which consists in releasing the new product/service or implement a new process/business model (Hakkarainen and Consulting, 2014; Bagno, Salerno and da Silva, 2017).

Table 7: Actors and actions suggest in the third phase (manufacturing, distribution and sales) of the innovation process

Actors	Actions suggested
SMEs	Focus on proactively performing competitive assessments of the research and development results that show potential to be transformed into commercial products; Integrate consortia that links them with companies from other countries enabling learning processes and accessing new funding opportunities, exposing them to new markets; Perform proactively a risk-assessment analysis that highlights the main problems and difficulties that they may have during the fulfilment of the innovation process.
Suppliers (large companies)	Align business agenda with the main research themes addressed by research centres in the ecosystem; Promote the integration of different parties in the innovation process. For that, it is necessary to strike a balance from its participation in the ecosystem (i.e. benefiting from it while, at the same time, promoting the emergence of new players); Considering the emergence of new players, leverage the existing physical and financial infrastructure to guide promising research towards the marketplace
Public authorities/government	Fund the development of a platform where the stakeholders of a healthcare innovation ecosystem can establish long-term relationships with underlying support structures; Create a national healthcare innovation strategy through the disclosure of opportunities to develop innovate solutions (at a regional, national and European levels); Develop a new approach to reduce the bureaucratic processes and make the information publicly available and easy to access; Review the current funding model of healthcare institutions, considering a value-based healthcare strategy, which aims to increase the investment in research, development, and innovation,

Considering the continuous role of the hospitals in the process, the following key approaches were identified. Hospitals must try to define an innovation agenda that they can manage in the medium and long-term relationships, being able to quantify the benefits of participating in the ecosystem. Also, they should promote

the participation of patients and staff in innovation projects by providing more information and showing its benefits to the users, promoting data collection, analysis and treatment for knowledge creation.

Hiring innovation managers, to supervise innovation processes in the hospital and the surrounding ecosystem, can play a decisive part in enhancing the role and responsibilities of the hospital in the innovation process. The integration of a knowledge and technology manager in the institution is important to ensure that the parties are levelled and are communicating on a *peer to peer* basis.

Also, it is suggested that according to the resources available, hospitals must try to leverage their position in the innovation process while seeking to obtain a more active role that can benefit their participation in this type of projects.

As it can be seen, a significant number of stakeholders can be identified in the healthcare innovation ecosystem as well as actions that each can take, which implies an intensive change of knowledge. From these results, this paper suggests the creation of an online platform where participants in the healthcare sector can find stakeholders to develop innovative solutions – from consortia identification to market results, ensuring the adequate funding mechanisms and support activities necessary to achieve these results.

As such, there is the need to implement knowledge flows management practices, to ensure successful collaborations. However, the role of the stakeholder depends on the goals of the ecosystem, the goals of each participant and the resources each party is willing to provide. This validates the use of the ecosystem approach, since it considers a large number of actors and the tensions that can emerge from the collaborations established.

Answering the research question, the creation and development of the ecosystem is only possible and activated if the existing strengths can be properly leveraged. This can happen through the creation of an innovation platform that ignites, guide and support the relationships between stakeholders during the entire innovation process life cycle. Along the process, there is also the need to implement knowledge management practices, that are complex in the public sector (Massaro, Dumay and Garlatti, 2015). However, some effort must be made to ensure that these practices are implemented. Also, the need to manage knowledge needs to be communicated between all the parties involved in the ecosystem, so that knowledge can flow and improve the work developed in the network.

5. Conclusion

Innovation has come a long way since the times it was defined just as a new idea. Nowadays, innovation activities range from the development of new products and/or services to improvements in organisational business models. The healthcare sector is no exception. Innovation in this sector as being increasing over time and in the last years it has occupied a prominent place in the national and European agenda.

With this study it was possible to observe that the healthcare innovation ecosystem can be analysed from different perspectives. However, it is important to emphasize the role of the hospital in the process, to achieve better results and improve their innovative capabilities. Using a case study approach, it will be possible to compare different contexts and achieve best practices on the management of healthcare innovation ecosystems.

Also, the need for more effective knowledge management and technology practices is evident to ensure that hospitals and the other parties meet their goals and play their role in the ecosystem.

Finally, to answer to the research question, our perception is clear. It is only possible to activate innovation and knowledge flows in healthcare ecosystems and ensure that all the participants benefit from its results and for that to happen, it is necessary to have a catalyser (an entity or individual) that is responsible for finding the best partnership opportunities to innovate.

5.1 Implications

This work has strived to understand the necessary conditions for the creation of such an ecosystem, identifying the current status quo, its strengths and weaknesses, as well as external opportunities and threats.

Based on the existing characteristics, a road map proposal was defined that can contribute to the emergence of a healthcare innovation ecosystem from which all parties can benefit and pursue, in a more rational and practical approach their research and business objectives. Also, this study identifies the pertinence of developing an online platform to manage the innovation ecosystem and its stakeholders, which currently does not exist in the country.

5.2 Limitations and future research suggestions

Although the paper provided guidelines for action, there is the lack of implementation of the suggestions in a specific context. So, this paper aims to serve as a basis for future research on the study of hospitals' innovation ecosystems and knowledge flows among the involved parties.

Moreover, the development of case studies regarding the creation, development and maintenance of hospital innovation ecosystems in different contexts could help to achieve best practices for its effective management. Also, the enrichment of the literature, with the analysis of different regions could help to foster innovation in countries with low levels of innovation in the healthcare sector, since they could learn from others and among each other.

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Appendix 1 - TOWS Analysis

	O01. Introduction of informatic software in the healthcare services	O02. Management of clinical data among stakeholders	O03. New business models	O04. Learn from other countries	O05. Manage clinical data to negotiate with pharmaceuticals and assess medical equipment in a large scale
S01. Public platform that gives importance to innovation in the healthcare sector	The connection between data from the system and the platform could help to identify innovation opportunities more easily according to the patterns	Connecting the data to identify hospitals where innovation is more rapidly growing	Identification of innovative opportunities to identify how hospitals can operate at a local level based on their experience	Learn from others of how they assess innovation opportunities	Data can help to benchmark partnerships, evaluating them periodically and create incentive mechanisms in the medium and long-term
S02. Structured and integrated information about what is being done in the healthcare sector, available for all users	Promote sharing of anonymous data from patients that can help to identify opportunities to develop innovative solutions	Help to identify opportunities for the implementation of innovative solutions	N/A	In learning from other countries, the data can help to identify which initiatives can be developed and which to leave	Data from patients can help to identify possible partnerships with pharmaceutical industry in the development of innovative solutions
S03. Large amount of organisation information available that allows to compare and assess hospitals' performance	Identify hospitals that are more suitable for the treatment of a patient and share information between hospitals to achieve best practices	The comparison of the information from organisations and the SPMS	Promote the use of data	Portugal can learn from other countries how they collect information from hospitals and even enter in contact with those hospitals to achieve best practices	Promote partnerships in the development of innovative solutions.
S04. Healthcare universities courses that implemented entrepreneurship disciplines in their curricular plan	The use of the data can help to test pilots.	In assessing institutions there is the opportunity to identify places where to implement, test and validate telemedicine projects	As telemedicine will change the business model, managers need to be aware of how it can impact the performance of the institution	Portugal can learn from other countries that are more advanced in the practice of telemedicine and achieve best practices at a European level	The availability of data from patients, even anonymous, can help to identify opportunities for the development of telemedicine

	Introduction of informatic software in the healthcare services	O02. Management of clinical data among stakeholders	O03. New business models	O04. Learn from other countries	O05. Manage clinical data to negotiate with pharmaceuticals and assess medical equipment in a large scale
W01. Technological innovation adoption is presented by the lack of partnerships in the ecosystem	The access to this data can help to discover innovation opportunities	The identification of how institutions are performing can help attract companies to collaborate with.	A business model composed by all the parties and their role must be defined	Other countries are fostering the connection between different parties surrounding the health ecosystem (for example, in November 2019, EHMA hosted a conference with this purpose)	Achievement of innovative solutions that are really in need in the market. Moreover, the involvement of patients as an active party can help to better assess innovations
W02. Lack of funding to hire hospital innovation managers	N/A	The identification of how institutions are performing can help to understand why they do not hire innovation managers	When developing new business models always considering the necessity of hiring an innovation manager	Innovation managers are frequently used in other countries, such as Sweden. Portugal needs to understand and learn how others are doing it	N/A
W03. Lack of a national healthcare innovation strategy	The data can help to identify if there is or there is not the need for this strategy	The data can help to identify if there is or there is not the need for this strategy	Promote a value chain composed by different stakeholders to transfer knowledge and technology to achieve innovative solutions	Portugal needs to analyse other countries' innovation strategy and learn how to develop and implement one	The involvement of the patients, that are part of the ecosystem and the principal "customer" can help to identify opportunities for the development of the strategy
W04. The SMEs and start-ups not focused on the development of products that can be scaled up	Data can help firm achieve other innovation opportunities beside service	Data can help companies identify hospitals to collaborate with in the development of innovative solutions.	Englobe companies in R&D phases throughout the entire business model	Portugal needs to learn from other countries how they are managing the introduction of home-companies in other phases besides service delivering	The data from patients can help companies to identify market opportunities
W05. Significant gap between R&D and market	Data can help to achieve innovative solutions that are in need in the market	Hospitals that are more suitable for a certain innovation can be identified as academic hospitals in which tests and pilots can be carried out and act as example for	Need to adapt the business model from hospitals as centres of testing	Portugal can learn from other countries in the assessment and selection of which innovations are in need and how to implement it	With the data from patients, innovations that are really in need can be identified. A more effective implementation can be achieved because it considers the human factor.

	Introduction of informatic software in the healthcare services	O02. Management of clinical data among stakeholders	O03. New business models	O04. Learn from other countries	O05. Manage clinical data to negotiate with pharmaceuticals and assess medical equipment in a large scale
		others to do the same			
W06. Knowledge creation process is focused on the academia with few contacts with the healthcare institutions	Data can help to achieve innovative solutions that are in need in the market	Hospitals can help researchers to connect more with companies establishing meetings between the parties to develop solutions in need to improve the hospital performance	Consider the role of the parties in the business model and the approach that can guide the process	Need for researchers to analyse case studies from other countries and even contact those researchers to see how the contact is established and what are the benefits	In developing case studies with patients and accessing data from them, researchers can understand how they can impact the real world with the contact established with companies in the development of innovative solutions
W07. Patients are not involved in the assessment of innovative solutions	The correct management of data can allow to select groups of patients to assess certain technologies depending on the health problem	Groups of patients in the hospitals can be identified as possible sources to be involved in the innovation process. Managers and those responsible for the innovation process need to be open for the patients' opinions	Involve the patients as a new approach for innovation as a value-based healthcare approach	Patients should be aware of international case studies and how the patients can act along the innovation process to understand the importance of their role.	Data from patients can help identify groups of people that are available to participate in the innovation process according to the necessities of the innovative solution and the patient

	T02. Lack of capacity for start-ups to access funding opportunities to scale up	T03. The new EU data policy obligates to a restrictive use of data	T04. Lack of time to market due to reduced funding for SMEs and start-ups	T05. The human is frequently ignored when considering the adoption of new technologies	T07. The healthcare sector in Portugal is mainly composed by public hospitals and the Ministry of Health is a direct competitor with the private healthcare technological organisations
S01. Public platform that gives importance to innovation in the healthcare sector	Considering the data from the platform there is the opportunity to identify where funding can be provided	The availability of the information can be used by organisations to identify health institutions to collaborate with	Considering the data from the platform there is the opportunity to identify where funding can be provided	N/A	This may lead the institution to not have the autonomy to choose who to collaborate with
S02. Structured and integrated information about what is being done in the healthcare sector, available for all users	Considering the data from the platform there is the opportunity to identify where funding can be provided	The availability of the information must be analysed according to the new norms	Considering the data from the platform there is the opportunity to identify where funding can be provided	The users should be involved and be able to give their opinion since they are the human factor that needs to be considered	This may lead the institution to not have the autonomy to choose who to collaborate with
S03. Large amount of organisation information available that allows to compare and assess hospitals' performance	Considering the data from the platform there is the opportunity to identify where funding can be provided	The availability of the information must be analysed according to the new norms	Considering the data from the platform there is the opportunity to identify where funding can be provided	Consider not only the organisations' information but also the involvement of patients in the process to consider a value-based healthcare approach	This may lead the institution to not have the autonomy to choose who to collaborate with
S04. Healthcare universities courses that implemented entrepreneurship disciplines in their curricular plan	Opportunity to develop programmes were students analyse those start-ups and develop projects of what can be done to improve their performance	N/A	N/A	Foster the development of case studies of how innovation processes occur in healthcare institutions	This may lead the institution to not have the autonomy to choose who to collaborate with

	T02. Lack of capacity for start-ups to access funding opportunities to scale up	T03. The new EU data policy obligates to a restrictive use of data	T04. Lack of time to market due to reduced funding for SMEs and start-ups	T05. The human is frequently ignored when considering the adoption of new technologies	T07. The healthcare sector in Portugal is mainly composed by public hospitals and the Ministry of Health is a direct competitor with the private healthcare technological organisations
W01. Technological innovation adoption is presented by the lack of partnerships in the ecosystem	It is necessary to involve all stakeholders	Considering the knowledge transfer involved in collaborations, the correct use of data must be assured	If companies want to incorporate high levels of knowledge in their exportable products, networks can provide the easier access to know-how, methods and techniques.	Due to the reduced importance given to the human factor also the role of patients in the ecosystem is not clearly defined	Due to the power of the Minister, this only will reduce when hospitals start to gain more autonomy in choosing who to collaborate with
W02. Lack of funding to hire hospital innovation managers	N/A	N/A	The reduction of funding made it difficult to hire such expertise which affects the performance of the innovation in the hospital, because managers are worried with aspects "more important" than innovation	N/A	Due to the power of the Minister, this only will reduce when hospitals start to gain more autonomy in choosing who to collaborate with
W03. Lack of a national healthcare innovation strategy	Define an healthcare innovation strategy involving start-ups	This strategy, must consider how to collect and manage data from hospitals, companies, patients, etc	N/A	Patients and group of representatives of patients need to be heard	The strategy must be developed and hospitals managers need to enhance the fact that hospitals need more autonomy
W04. The SMEs and start-ups not focused on the development of products that can be scaled up	Interconnect companies within networks, in order to scale up businesses	The new EU norms make it clear that companies must provide public reports of their activities.	Reducing budgets of providers of health and research may reduce companies' incentives to maintain (or create new) connections with enterprises dedicated to the same area of activities	This proves that the human factor is neglected most of the time	Due to the power of the Minister, this only will reduce when hospitals start to gain more autonomy in choosing who to collaborate with

	T02. Lack of capacity for start-ups to access funding opportunities to scale up	T03. The new EU data policy obligates to a restrictive use of data	T04. Lack of time to market due to reduced funding for SMEs and start-ups	T05. The human is frequently ignored when considering the adoption of new technologies	T07. The healthcare sector in Portugal is mainly composed by public hospitals and the Ministry of Health is a direct competitor with the private healthcare technological organisations
W05. Significant gap between R&D and market	Start-ups should search for new funding opportunities	The measures introduced by the EU can affect the implementation of innovative solutions due more bureaucratic processes to assure that the information is correctly used	Reducing budgets of providers of health and research may reduce companies' incentives to maintain (or create new) connections with enterprises dedicated to the same area of activities	Understand more deeply the population to facilitate the development and introduction of new technologies	Due to the power of the Minister, this only will reduce when hospitals start to gain more autonomy in choosing who to collaborate with
W06. Knowledge creation process is focused on the academia with few contacts with the healthcare institutions	Start-ups can be used as places where to test researchers' ideas and considering the dimension of the university, the start-up can make a deal to use it in their favour through for example promotion of collaboration between the parties	The knowledge transferred between the parties must be managed according to the EU norms which can act as a disadvantage due to the bureaucratic processes	The reduction of funding made it difficult to develop incentive programmes	Development of case studies.	Case studies can help to proof this as well as identifying solutions for this problem (e.g. a reformulation of the system)
W07. Patients are not involved in the assessment of innovative solutions	Need for more funding and recognition of start-ups as safe places	The involvement of the patients must assure that the patient authorises the use of the information	The reduction of funding made it difficult to develop incentive programmes	Understand more deeply the population to facilitate the development and introduction of new technologies	Patients are not seen as part of the ecosystem by the government. There is the need to include the people